AD NUMBER

AD474474

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; OCT 1965. Other requests shall be referred to Air Force Systems Command, Research and Technology Division, Attn: Systems Engineering Group [SEMCS],

AUTHORITY

USAEA ltr 27 Jun 1971

SECURITY MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.
Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

SEG-TR-65-49 FA Report M66-9-1

FEASIBILITY STUDY OF PERCUSSION PRIMERS BETWEEN 400° and 600° F

TECHNICAL REPORT SEG-TR-65-49

by

THEODORE B. JOHNSON
JOSEPH. F. KENNEY
(Remington Arms Company, Inc.)

October 1965

SYSTEMS ENGINEERING GROUP
Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

Prepared under AF MIPR 33-657-3-1375A-188
under Frankford Arsenal Contract DA-19-020-507-ORD-5153

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

DDC AVAILABILITY

Qualified requesters may obtain copies from DDC. Release to CFSTI is not authorized.

DISPOSITION INSTRUCTIONS

Copies of this report should not be returned to the Research and Technology Division unless return is required by security considerations, contractual obligations, or notice on a specific document.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

SEG-TR-65-49 FA Report M66-9-1

FEASIBILITY STUDY OF PERCUSSION PRIMERS BETWEEN 400° and 600° F

by

THEODORE B. JOHNSON
JOSEPH F. KENNEY
(Remington Arms Company, Inc.
under FA Contract DA-19-020-507-ORD-5153)

AF MIPR 33-657-3-1375A-188

Propellant Actuated Devices Division
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

for

Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

October 1965

FOREWORD

This research is part of a continuing effort to provide percussion primers having a high temperature capability for propellant actuated devices (PAD). The research work in this report was performed by Remington Arms Company, Inc., Bridgeport, Connecticut, on Frankford Arsenal contract DA-19-020-507-ORD 5153 (Phase III), under the technical supervision of Mr. T. Stevenson of the Chemistry Research Laboratory, Frankford Arsenal.

The program was performed under Air Force MIPR No. 33-657-3-1375A-188, with Mr. A. S. Mastriana of the Systems Engineering Group (SEMCS), Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, as the project engineer. Mr. H. D. MacDonald, Jr., was the Frankford Arsenal project engineer.

This report was submitted by the authors 17 July 1965. It has been reviewed and is approved.

GP Santi

G. P. SANTI
Chief, Crew Support Division
Directorate of Crew & AGE
Subsystems Engineering

ABSTRACT

Experimental work was conducted on previously developed percussion primers to determine functioning characteristics in the temperature range of 400° to 600° F. Feasibility studies were also conducted with various priming mixtures and metallic components of the primers to determine practicability of a primer which would be stable after several hours in storage at temperatures up to 600° F. Two primers, designated No. 73 (G-11) and No. 73 (G-16), were tested while being held at the high storage temperatures and, also, at ambient conditions after cooling from the storage temperature.

The sensitivity of No. 73 (G-11) primed, foiled cases was determined after exposure at 450° F. The results indicate that no reliance can be placed on these primers after an exposure of approximately one week at 450° F. G-11 primers may burn or explode after several hours at 500° F.

The sensitivity of No. 73 (G-16) primed, foiled cases was determined after exposure at 450°, 500°, 550°, and 600° F. The period of usefulness appears to range from several weeks at 450° F to several hours at 550° F. G-16 primers exploded after less than 30 minutes in a 600° F environment.

In the evaluation of ideas for primer components that might yield primers with increased temperature stability, it was shown that copper-plated steel components charged with G-16 mixture resulted in less change in sensitivity on storage at 500° F than did either brass or unplated steel components.

TABLE OF CONTENTS

Page

INTRODUCTION 1

PROCEDURES AND RESULTS 3

Room Temperature Sensitivity Tests of Conditioned Primers. 3

Elevated Temperature Sensitivity Tests of Conditioned Primers 9

Study of Materials for Primer Components 9

Study of Priming Mixture Ingredients 13

DISCUSSION

Room Temperature Sensitivity Tests of Conditioned Primers. 14

Elevated Temperature Sensitivity Tests of Conditioned Primers 15

Study of Materials for Primer Components 16

Study of Priming Mixture Ingredients 17

CONCLUSIONS 17

RECOMMENDATIONS 19

DISTRIBUTION 20

List of Illustrations

Figure

1. Primer, Nos 73 (G-11) and 73 (G-16) 2

2. Assembly, Equipment, Hot Drop Test 10

List of Tables

Table

1. Results, Preliminary High Temperature Storage Tests, 73 (G-16) Primers 4

2. Results, Preliminary 450° F Storage Test, 73 (G-11) and 73 (G-16) Primers in Aluminum Foiled 7.62 mm Cases . . . 5

List of Tables (Cont'd

Table		Page
3.	Results, Room Temperature Testing after 550° F Storage, 73 (G-16) Primers in Foiled 7.62 mm Cases.	6
4.	Results, Room Temperature Testing after 500° F Storage, 73 (G-16) Primers in Foiled 7.62 mm Cas s.	7
5.	Results, Room Temperature Testing after 450° F Storage, 73 (G-11) and 73 (G-16) Primers in Foiled 7.62 mm Cases.	8
6.	Results, Elevated Temperature Drop Tests, 73 (G-11) and 73 (G-16) Primers in Foiled 7.62 mm Cases.	11
7.	Results, Elevated Temperature Drop Tests, Stored 73 (G-16) Primers in Foiled 7.62 mm Cases.	12
8.	Results, 500° F Storage Test, 73 (G-16 Primers, Steel Components, in Foiled 7.62 mm Cases.	12
9.	Priming Mixture Formulas	13
10.	Results, 400° F Storage Test, 73 (G-23) Primers in Foiled 7.62 mm Cases	13
11.	Results, 400° F Storage Test, Primers with P-4 Mixture .	14

INTRODUCTION

To improve the high temperature stability of primers used in propellant actuated devices (PAD), a contract (DA-19-020-507-ORD -5153) was awarded to Remington Arms Company, Inc., by Frankford Arsenal, Philadelphia, Pennsylvania. This report covers studies conducted under Phase III of this contract.

Under Phases I and II, the original goal of primer storage for 2000 hours at 400° F was approached by the development of two primers which were coded by numbers 73 (G-11) and 73 (G-16). This nomenclature signifies No. 73 primer components charged with G-11 mix and No. 73 primer components charged with G-16 mix. The basic components of these designs are indicated in the drawing in Figure 1; the formulas for the priming mixtures are given in the following tabulation.

	G-11	G-16
Potassium chlorate	53	53
Antimony sulfide	25	30
Calcium silicide	12	17
TACOT	10	-

Experiments conducted under Phase II of the contract showed that dezincification of the brass components occurred after prolonged storage at 400° F, together with a loss of sensitivity when previously stored primers were held at 72° F temperature and 64% relative humidity conditions for a period of two weeks. Other experiments, however, indicated that selected metal components or plating of metal components would probably provide significant improvement. There was some evidence to indicate that exposure to temperatures above 400° F might be tolerated for short periods, particularly with the G-16 priming mixture.

The aim of the studies was to identify primer composition and materials problems and, also, to provide a probable target specification for the next generation of percusssion primers capable of storage and use above 400° F. Therefore, the primary objectives of the Phase III work, reported here, were:

1. To investigate the room temperature sensitivity of 73 (G-16) and 73 (G-11) primers after storage at temperatures between 400° and 600° F.

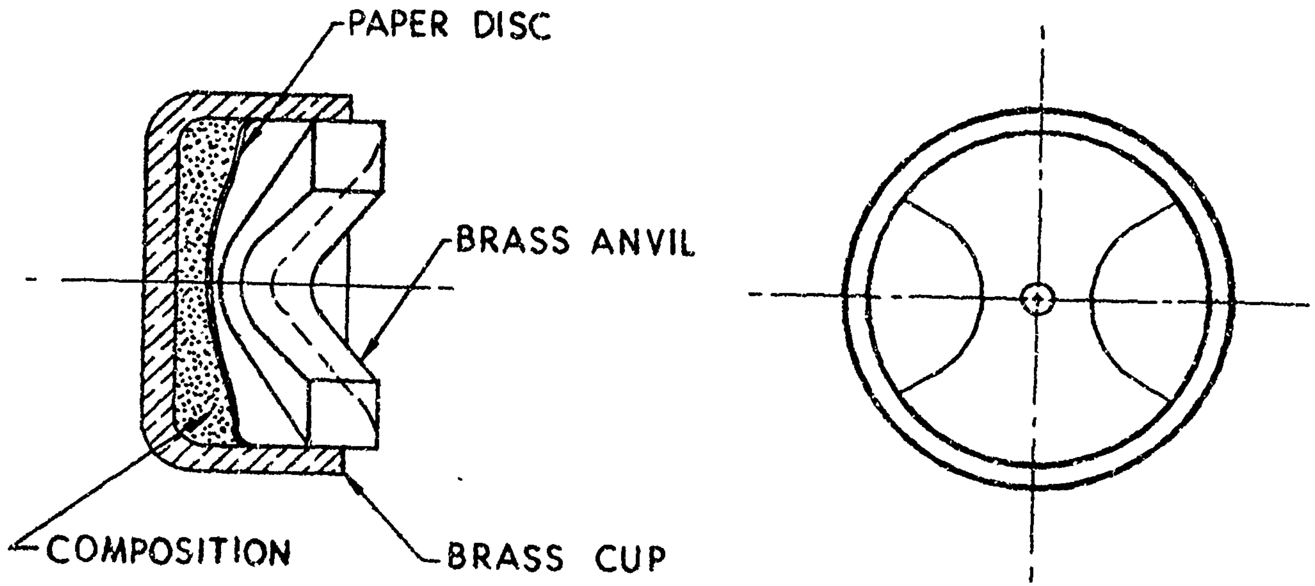

Figure 1. Primer, Nos 73 (G-11) and 73 (G-16)

2. To investigate the high temperature sensitivity of 73 (G-16) and 73 (G-11) primers tested while being held at temperatures between 400° and 600° F, and the difficulties that might be encountered at 600° F.

3. To determine priming mixture ingredients and metallic components which would be stable in a primer after several hours' storage at temperatures up to 600° F.

This report provides a detailed explanation of the methods used and results obtained by the contractor in conducting these studies. Essentially, the investigation was conducted in four distinct subphases:

1. Room temperature sensitivity tests of conditioned primers;

2. Elevated temperature sensitivity tests of conditioned primers;

3. A study of materials for primer components;

4. A study of priming mixture ingredients.

PROCEDURES AND RESULTS

Room Temperature Sensitivity Tests of Conditioned Primers

Prior to full scale storage tests at temperatures above 400° F, preliminary tests were made at 50° intervals between 400° and 600° F to determine: (1) the hazards connected with the storage of primers at these temperatures; (2) the approximate duration of storage at each temperature and, hence, the size of the sample necessary for the full scale tests.

Results of the preliminary tests (shown in Table 1 and 2), indicated:

1. The 73 (G-16) primers ignited at 600° F in less than 1/2 hour.

2. The 73 (G-16) primers showed some sensitivity after one hour at 550° F or after 24 hours at 500° F.

3. The sensitivity of 73 (G-16) and 73 (G-11) primed shells decreased steadily with time at 450° F. The level of sensitivity

TABLE 1.

Results, Preliminary High Temperature Storage Tests,
73 (G-16) Primers
(4-oz weight)

Storage Temperature (°F)	Storage Time (hr)	Sensitivity Results at 72° F
		Primers
600	1/2	All (7/7) ignited in oven.
550	1/2	3 out of 5 fired at 12 in.
	1	2 out of 5 fired at 12 in.
	1-1/2	0 out of 5 fired at 12 in.
500	0	4 out of 5 fired at 12 in.
	4	5 out of 5 fired at 12 in.
	7	4 out of 5 fired at 12 in.
	24	4 out of 5 fired at 12 in.
		Primers, Aluminum Foiled, in 7.62 mm Cases[a]
500	0	$\bar{X}$[b] = 9.4 in.
	24	$\bar{X}$ = 13.2 in.
	48	$\bar{X}$ = 16.6 in.
	72	$\bar{X}$ = 20.8 in.
	120	1 out of 25 fired at 25 in.
450	1	$\bar{X}$ = 9.1 in.
	24	$\bar{X}$ = 9.3 in.
	72	$\bar{X}$ = 10.4 in.
	144	$\bar{X}$ = 11.0 in.
	240	$\bar{X}$ = 12.6 in.

[a]25-primer Bruceton type test. (Bruceton method - Ordnance Corps Pamphlet ORDP 20-111, "Experimental Statistics," Section 2, pp 10-22, 10-23.)

[b]$\bar{X}$ = mean firing height.

TABLE 2.

Results, Preliminary 450° F Storage Test,
73 (G-11) and 73 (G-16) Primers in Aluminum Foiled 7.62 mm Cases
(25-primer Bruceton type Tests at 72° F)

Test[a]	Storage Time at 450° F (hr)	Mean Firing Height ($\bar{X}$)[b] (in.) 73 (G-11)	73 (G-16)
A	0	8.1	9.3
	24	8.2	9.3
	48	8.4	9.7
	72	8.8	9.9
	96	8.8	9.9
	144	8.8	10.7
	168	9.7	11.0
	216	9.7	11.1
	312	9.7	11.0
B	0	8.3	9.8
	360	9.0	10.9
	528	9.1	11.4
	696	14.2	13.1
	864	9.5	13.2
	1008	11.2	14.1
	1176	13.6	14.9

[a]Samples depleted at end of test A; new samples used in test B, but primers from same manufacturing lots as in test A.

[b]Four-oz weight in all tests.

(i.e., the mean firing height, $\bar{X}$) still appeared satisfactory after one to three weeks, although this needed to be verified by complete run down tests.

Following these preliminary tests, large samples of 7.62 mm NATO cases were primed with 73 (G-16) or with 73 (G-11) primers, with 0.010 inch thick aluminum covering the flash hole. Brass cases were used because they were readily available. The aluminum seal was applied at the primer insertion operation by blanking from strip.

For the comparatively short duration of 550° and 500° F tests, the effect of "heat up" time was partially eliminated by placing the shells in a 450° F oven for 30 minutes before starting storage. (The preliminary tests had shown that 30 minutes at 450° F had no appreciable effect on sensitivity.)

On removal from the high temperature ovens, samples were immediately placed on a bench in the oven room and allowed to remain there for one-half to one hour. After this time they could be handled safely, and they were then removed to the drop test room, which was held at 72° F and about 64% relative humidity. Thus, drop tests were started one to two hours after the primers had been removed from the oven. Drop test results after storage at temperatures between 400° and 600° F are shown in Tables 3, 4, and 5, and are discussed in the body of the report.

It was noted that several G-11 primers would not fire after one week of storage at 450° F, which indicated an abrupt change from results obtained at 400° F in an earlier phase of the program. This would not have been observed in a Bruceton type test and, in fact, was not observed in the preliminary tests (Table 2), although the estimated mean firing heights were identical in the two tests.

TABLE 3.

Results, Room Temperature Testing after 550° F Storage
73 (G-16) Primers in Foiled 7.62 mm Cases

Storage Time[a] at 550° F (hr)	$\bar{X}$ (in.)	σ (in.)	$\bar{X} + 3\sigma$ (in.)
0.5	9.96	1.25	13.71
1.0	10.30	1.37	14.41
1.5	10.56	0.97	13.47
2.0	10.70	1.01	13.73
3.0	11.38	1.05	14.53
4.0	12.10	1.36	16.18
5.0	12.74	1.79	18.11

[a]Time indicated is actual time the shells were in the 550° F oven. The effect of "heat up" time was partially overcome by placing the shells in a 450° F oven for 30 minutes before starting storage at 550° F. It had been shown that 30 minutes at 450° F has no appreciable effect on sensitivity.

NOTE: Run-down; 25 at each one-inch interval; 50 at high clearance. Four-oz weight, at 72° F.

TABLE 4.

Results, Room Temperature Testing after 500° F Storage
73 (G-16) Primers in Foiled 7.62 mm Cases

Storage Time[a] at 500° F (hr)	$\bar{X}$ (in.)	σ (in.)	$\bar{X} + 3\sigma$ (in.)
0	9.08	1.34	13.20
2	9.32	1.41	13.55
4	9.02	1.36	13.10
6	9.68	1.37	13.79
8	9.62	1.31	13.55
10	9.60	1.20	13.20
12	10.18	1.09	13.45
14	10.00	1.08	13.24
16	10.04	1.19	13.61
18	10.10	1.39	14.27
20	10.78	1.48	15.22
22	10.82	1.29	14.69
24	11.22	1.43	15.51
26	10.80	1.12	14.16
28	10.94	1.33	14.93
30	11.92	1.40	16.22
32	12.26	1.79	17.63

[a]Time indicated is actual time the shells were in the 500° F oven. The effect of "heat up" time was partially overcome by placing the shells in a 450° F oven for 30 minutes before starting storage at 550° F. It had been shown that 30 minutes at 450° F has no appreciable effect on sensitivity.

NOTE: Lot plant-charged 10 Sep 63. Run-down; 25 at each one-inch interval; 50 at high clearance. Four-oz weight, at 72° F.

TABLE 5.

Results, Room Temperature Testing after 450° F Storage
73 (G-11) and 73 (G-16) Primers in Foiled 7.62 mm Cases

Storage Time at 450° F	73 (G-11)			73 (G-16)		
(hr)	$\bar{X}$ (in.)	σ (in.)	$\bar{X} + 3\sigma$ (in.)	$\bar{X}$ (in.)	σ (in.)	$\bar{X} + 3\sigma$ (in.)
0	7.66	1.46	12.04	9.52	1.39	13.69
168	9.7	a	a	10.94	1.30	14.84
336	9 to 10	a	a	12.46	1.68	17.50
504				12.40	1.82	17.86
672				12.14	1.79	17.51
840				13.28	1.87	18.89

[a]Estimated; no clearance.

NOTE: Lot plant-charged 10 Sep 63. Run-down; 25 at each one-inch interval; 50 at high clearance. Four-oz weight, at 72° F.

During earlier testing, when 7.62 mm foiled cases were stored for protracted periods of time at 400° F, there was no evidence of the presence of any completely inert primers.* Complete run-down curve tests after 3500 hours at 400° F did not fail to give an upper clearance height. On some tests there were indications of increased positive skewness after storage at 400° F, but in all tests reasonable clearance heights were obtained with a sample size of fifty.

In view of the results of the 450° F test, the individual curve test results at 400° F were reviewed in order to be sure that the preceding remarks correctly portray this picture. This breakdown phenomenon appears to become accentuated, therefore, between 400° and 450° F.

Further consideration of the 400° F tests also revealed that there may be a correlation between sensitivity and the time between removal from the high temperature oven and testing. A test on primed cases stored for 2520 hours at 400° F and allowed to stand for two weeks before testing showed significantly poorer sensitivity than preceding or succeeding samples that were tested about two hours after removal from storage.

In addition to drop test sensitivity, cartridge ignition tests were made on several samples of primed shells that had been stored at high temperatures. Samples of 73 (G-16) primers stored for 168

*Final Summary Report, Phase II, AB-62-10, Remington Arms Company, Inc., Sep 62.

hours at 450° F and for 22 hours at 500° F were obtained by cutting down stored primer cases. Along with a sample of unstored primers, they were loaded into 7.62 mm cartridges and fired at ambient temperature. Pressure and velocity were normal for all samples; i.e., about 52,000 psi and 2800 fps. Action times for the stored samples were somewhat increased. With the disjunctor five feet from the muzzle, standard ammunition gave times of four milliseconds; the unstored 73 (G-16) gave 4.8 milliseconds, while the stored primers gave times in the 31 to 39 millisecond range.

Elevated Temperature Sensitivity Tests of Conditioned Primers

For drop tests at elevated temperatures, the standard steel drop test die holder was replaced by an aluminum block fitted with heater, firing pin bushing, and thermocouple well, as shown in Figure 2. Standardization and calibration tests indicated that if the primed shells were first preheated in the heated die, equilibrium was reached in about 1-1/2 to 2 minutes.

It was necessary to place a 1/2 inch sheet of Transite between the heated die assembly and the bed of the drop test stand in order to minimize heat losses. This gave enough cushioning to raise the $\bar{X}$ about 11 to 14 percent in room temperature tests on 73 (G-11) and 73 (G-16) primed shells (Table 6). It must be presumed that some unknown part of this increase appears in the high temperature tests, but comparative tests in the heat die appear reasonable and valid. As was already known for lower temperatures, the $\bar{X}$ decreased with increased temperature; at 500° F, the mean firing heights were about 40 percent of the 72° F values. Table 7 indicates the results obtained from tests conducted at 450° and 500° F with 73 (G-16) primed cases which had been stored at these same temperatures. These conditions consisted of:

1. Storage for 168 hours at 450° F and then tested at 450° F;

2. Storage for 32 hours at 500° F and then tested at 500° F.

Study of Materials for Primer Components

Number 73 type primer cups and anvils were made from 1010 steel and plated with copper. Charged with G-16 priming mixture, the steel component primers, unplated and copper plated, were assembled into foiled 7.62 mm cartridge cases and stored at 500° F. The effect of "heat up" time was partially overcome by placing the shells in a 450° F oven for 30 minutes before starting storage at 500° F. Room temperature drop tests were run on samples withdrawn at 24-hour intervals for five days. The results are shown in Table 8.

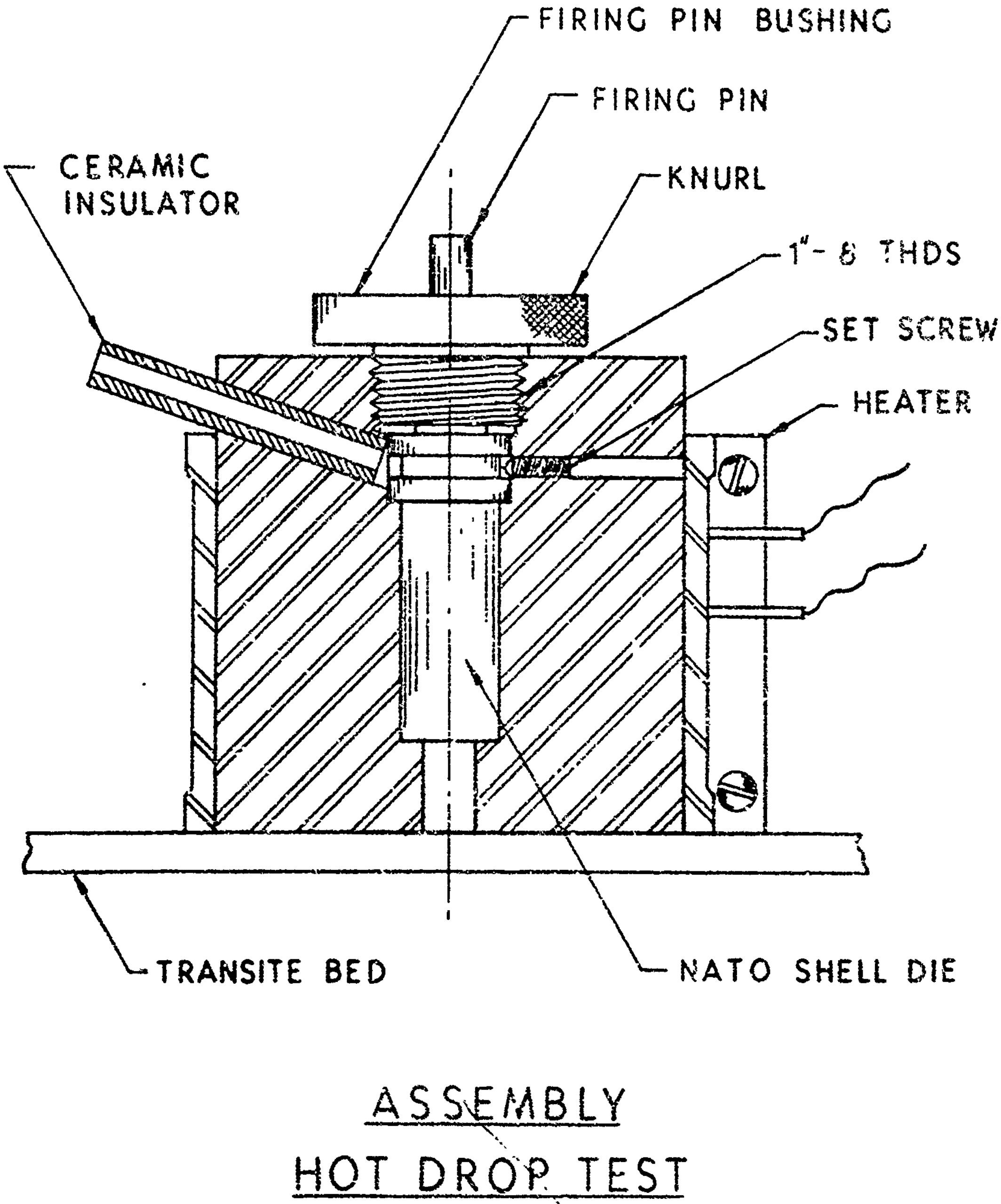

Figure 2. Assembly, Equipment, Hot Drop Test

TABLE 6.

Results, Elevated Temperature Drop Tests
73 (G-11) and 73 (G-16) Primers in Foiled 7.62 mm Cases

Temperature (°F)		73 (G-11)			73 (G-16)		
Test[a]	Preheat[b]	$\overline{X}$ (in.)	σ (in.)	$\overline{X} + 3\sigma$ (in.)	$\overline{X}$ (in.)	σ (in.)	$\overline{X} + 3\sigma$ (in.)
72	-	8.5	1.7	13.6	10.8	0.6	12.6
400	350	5.9	0.6	7.7	5.9	0.6	7.7
450	400	4.9	0.4	6.1	5.3	0.5	6.8
500	425	3.6	0.6	5.4	4.0	0.4	5.2
550	425	-	-	-	2.8	0.3	3.7

[a]One and one-half minutes were allowed for equilibrium at 400° and 450° F; two minutes were allowed at 500° and 550° F.

[b]Preheat time was 30 minutes.

NOTE: Lots plant-charged 10 Sep 63.
25-primer Bruceton tests; one-inch intervals; 4-oz weight.

TABLE 7.

Results, Elevated Temperature Drop Tests,
Stored 73 (G-16) Primers in Foiled 7.62 mm Cases

Storage Time (hr)	Temperature (°F) Storage	Temperature (°F) Test	$\bar{X}$ (in.)
0	-	72	10.8
0	-	450	5.3
168	450	450	5.8
0	-	500	4.0
22	500	500	4.8
32	500	500	5.4

NOTE: Lot plant-charged 10 Sep 63.
25-primer Bruceton Tests; one-inch intervals; 4-Oz weight.

TABLE 8.

Results, 500° F Storage Test
73 (G-16) Primers, Steel Components, in Foiled 7.62 mm Cases

Storage Time[a] at 500° F (hr)	$\bar{X}$ (in.) Copper Plated Components	$\bar{X}$ (in.) Unplated Components
0	11.7	12.1
24	12.2	Misfires at 25 in.
48	12.5	
72	13.3	
96	14.1	
120	15.5	

[a]Time indicated is actual time in the 500° F oven. The effect of "heat up" time was partially overcome by placing the shells in a 450° F oven for 30 minutes before starting storage at 500° F. It had been shown that 30 minutes at 450° F has no appreciable effect on sensitivity.

NOTE: Lot plant-charged 10 Sep 63.
25-primer Bruceton test; 4-oz weight, at 72° F.

Study of Priming Mixture Ingredients

Table 9 indicates the percent composition of the various priming mixtures used in this investigation. The results of tests conducted after storage of up to nine weeks at 400° F are shown in Table 10.

TABLE 9.
Priming Mixture Formulas

	G-11	G-16	G-18	G-19	G-20	G-21	G-22	G-23	FA670 P-4
Potassium chlorate	53	53	-	-	53	53	53	53	-
Potassium perchlorate	-	-	53	53	-	-	-	-	-
Antimony sulfide	25	30	30	30	-	-	-	-	-
Calcium silicide	12	17	17	-	30	17	17	30	-
Zirconium (Gran C)	-	-	-	17	17	-	-	-	-
Iron phosphide	-	-	-	-	-	30	-	-	-
Ferrous sulfide	-	-	-	-	-	-	30	-	-
Cuprous thiocyanate	-	-	-	-	-	-	-	17	-
TACOT	10	-	-	-	-	-	-	-	-
Barium nitrate	-	-	-	-	-	-	-	-	80
Red phosphorus	-	-	-	-	-	-	-	-	20

TABLE 10.
Results, 400° F Storage Test
73 (G-23) Primers[a] in Foiled 7.62 mm Cases

Storage Time at 400° F (hr)	$\bar{X}$ (in.)
0	5.0
168	7.1
336	7.2[b]
504	8.4[c]

[a]Cuprous thiocyanate mixture.
[b]Several hangfires.
[c]All fires were hangfires.

NOTE: 25-primer Bruceton test; 4-oz weight, 72° F.

The evaluation of P-4 priming mixture consisted of storing the test primers at 400° F for up to four weeks. A portion of the sample primers were removed at one-week intervals and tested after allowing them to cool to 72° F. The P-4 primer mix was loaded in three different types of test primers. One type of primer used a zinc die-cast anvil with an aluminum cup which was made to No. 72 primer dimensions. A second type of primer combined a standard No. 72 brass primer cup and conventional round nose anvil coated with shellac. The third type used an aluminum cup and round nose anvil made to No. 73 primer dimensions.

The shellac-coated brass components delivered the best results, as indicated in Table 11. Maximum storage time at 400° F for this mixture would appear to be less than 336 hours.

TABLE 11.
Results, 400° F Storage Test,
Primers with P-4 Mixture

	$\bar{X}$ (in.)		
Storage Time at 400° F (hr)	72 (P-4) Primers[a] Aluminum Cup, Zinc Die-cast Anvil	72 (P-4) Primers[b] Shellaced Brass Cup and Anvil	73 (P-4) Primers[c] Aluminum Cup and Anvil
0	11.3	5.1	5.8
168	Misfires up to 25 in.	7.2	11.1
336	Misfires up to 35 in.	9.8	14.9
504	-	18.6	Misfires up to 30 in.
672	-	16 misfires out of 20 between 20 and 30 inches.	Misfires at 30 in.

[a]Cup was made to No. 72 primer dimensions because zinc die-cast anvil was available only in the size to fit that cup.
[b]Standard No. 72 primer cup and conventional round nose anvil coated with shellac.
[c]Aluminum cup and round nose anvil made to No. 73 primer dimensions.

NOTE: 25-primer Bruceton test; tested at 72° F with 4-oz weight.

DISCUSSION

Room Temperature Sensitivity Tests of Conditioned Primers

Preliminary tests were conducted to obtain results which would allow for a better definition of experimental parameters applicable to more extensive testing. These initial tests, the results of which

are shown in Tables 1 and 2, were made to determine the sensitivity of 73 (G-16) primed foiled cases after exposure at 450°, 500°, and 600° F. It was found that the period of usefulness, depending, of course, on specific sensitivity requirements, appeared to range from several weeks at 450° F to several hours at 550° F. G-16 primers exploded after less than 30 minutes in a 600° F environment.

The sensitivity of 73 (G-11) primed foiled cases was determined after exposure at 450° F. The results indicated that no reliance can be placed on these primers after an exposure of one week or more at 450° F. G-11 primers may burn or explode after several hours at 500° F.

More extensive testing of the sensitivity of 73 (G-16) and 73 (G-11) primers was then initiated. The first phase testing consisted of storing the primers for different lengths of time at temperatures varying from 450° to 550° F. After heating for specified times, they were removed from oven storage, allowed to cool to room temperature (72° F), then submitted to standard drop test procedure. The results of these tests are shown in Tables 3, 4, and 5.

In addition to drop test sensitivity, cartridge ignition tests were made on several samples of primed shells that had been stored at 450° and 500° F. Pressure and velocity were measured at ambient temperature and compared with results obtained with unstored shells and primers. There appeared to be little change, although a definite increase in ignition time was evident. Additional details of these tests are contained in the description of experimental procedures.

Elevated Temperature Sensitivity Tests of Conditioned Primers

Essentially, the second phase of testing consisted of the same procedure as the first, except for one important difference - the primers were not allowed to cool to room temperature, but were tested at the particular elevated temperature in question. A heated die (shown in Figure 2) was designed and fabricated for the drop test equipment. The sensitivity of 73 (G-16) and 73 (G-11) primers loaded in foiled cases was measured in the 400° to 550° F range, as well as at 72° F, with this equipment (see Table 6). The primed shells were first preheated to within 50° to 100° F of the test temperature and then placed in the heated die. Times of 1-1/2 minutes at 400° and 450° F and two minutes at 500° F were allowed for reaching equilibrium prior to testing.

Using the results obtained with the primers maintained and tested at 72° F as a standard for comparison, it can be noted that the effect of increasing the temperature at which the tests were

performed was to reduce the mean firing height. In comparing the performance of the G-11 primers, the data indicated that at 400° F the mean firing height was reduced to about 70 percent of the height obtained at 72° F testing. This height was reduced even further, to approximately 40 percent of the standard, when the primers were tested at 500° F.

Similar tests conducted with the G-16 primers indicated the same trend of reduction in mean firing height with increased temperature. Tests conducted at 400° F indicated the mean firing height decreased to approximately 55 percent of the results obtained at 72° F; tests conducted at 500° and 550° F reduced this figure to 37 and 26 percent, respectively.

A few tests were made at 450° and 500° F with 73 (G-16) primed cases which also had been stored at these same temperatures. These conditions consisted of:

1. Storage for 168 hours at 450° F and then tested at 450° F.

2. Storage for [illegible] hours at 500° F and then tested at 500° F.

As can be seen by comparison of the results, shown in Table 7, the mean firing height of the stored sample in each case was about half that of the unstored primers which were fired at 72° F. At 450° F, the increase in mean firing height of the stored sample over the unstored sample was about 10 percent. The sample stored and tested at 500° F, when compared with the unstored sample tested at 500° F, showed an increase in mean firing height of 20 percent (22 hours) and 35 percent (32 hours).

Study of Materials for Primer Components

The third phase of this study concentrated on the evaluation of ideas for primer components that might yield primers having increased stability after storage in the 400° to 600° F temperature range. In this study, defects observed with the current brass cups and anvils were caused by chemical corrosion (evident at mixture contact points) and annealing. The corrosion appeared to be caused largely by dezincification, but there also appeared to be some copper oxidation.

From a metallurgical standpoint, steel seemed to be a logical starting choice for investigating new materials for primer components. Its physical properties will remain unchanged at the contemplated temperatures, and fabrication is easier than with materials such as titanium or some of the nickel and chromium alloys.

Furthermore, it appeared possible to protect against corrosion by plating. Consequently, No. 73 type primer cups and anvils were made from 1010 steel and plated with copper. It was thought that copper would give better protection than bare steel or brass. The results of tests conducted after storage at 500° F (Table 8) indicated that while these primers were not quite as sensitive as those with brass components, there is somewhat less change in sensitivity over three days than occurred in 24 hours with brass components (Table 4). Also, the copper plating of the steel components helped considerably as a similar sample without the copper plate would not fire with a 25-inch ball drop after only one day's storage at 500° F.

Study of Priming Mixture Ingredients

A similar investigation of priming mixture ingredients was less fruitful. Table 9 indicates the percent composition of the various mixtures. The use of the following ingredients resulted in primers that were insensitive: (1) granulation C zirconium, iron phosphide, or ferrous sulfide in place of antimony sulfide or calcium silicide, and (2) potassium perchlorate in place of potassium chlorate in the G-16 type mixtures.

Cuprous thiocyanate in a G-16 type mixture resulted in excellent sensitivity, but stability was not good, even at 400° F (see Table 10). The cuprous thiocyanate mixture may be useful where high sensitivity is required.

The evaluation of P-4 priming mixture included investigation of a red phosphorus composition in aluminum components, a zinc die-cast anvil, and shellacked brass components. The test results are shown in Table 11. Although none of the samples approached 2000 hours' storage, the primers with shellacked brass components did deteriorate more slowly than the others. However, this composition may have value at 400° F and should be included in future investigations.

CONCLUSIONS

In general, percussion primer sensitivity increases as exposure temperatures and times increase. However, once a primer has been exposed to high temperatures, an accurate prediction of its performance becomes increasingly difficult to estimate. It should be noted that primer mixture properties do not become frozen at any particular temperature. These properties will vary, not only with temperature but also with exposure time to that temperature. After a primer

has been stored for a time at an elevated temperature, another variable is introduced if the primer is allowed to cool to and remain at room temperature prior to testing. This last effect on sensitivity will vary, depending upon the severity as well as the length of exposure time of the elevated temperature. To a varying degree, it may even be less sensitive than the original unstored primer. Usually, the longer the primer is allowed to remain at room temperature after removal from high temperature storage, the more pronounced is this reduction in sensitivity.

Comprehensive statements as to the "goodness" or "badness" of primed shells after high temperature storage will not be attempted, since such statements would depend on evaluation under the conditions of contemplated usage. However, under the conditions of storage and testing described in this report, No. 73 (G-16) primed shells appear to fire reliably after limited exposure to elevated temperatures up to 550° F. The period of usefulness, depending of course on specific sensitivity requirements, appears to range from several weeks at 450° F, to a day or less at 500° F, to several hours at 550° F.

The sensitivity of 73 (G-11) primed foiled cases was determined after exposure at 450° F. Results indicated that no reliance can be placed on these primers after an exposure of one week or more at 450° F. After several hours at 500° F, these primers may burn or explode. The results of the 73 (G-11) tests at 450° F indicated that a certain number of primers (15 to 20 percent) would not fire under any blow. Comparison with results of tests performed at 400° F indicates that a breakdown phenomenon appears to become accentuated between 400° and 450° F. There also appears to be a correlation between sensitivity and the time between removal from the high temperature oven and testing. Therefore, the nature and duration of the primer environment between high temperature storage and testing should be investigated in future work.

In the investigation of primer components and materials to increase primer stability, it was shown that copper plated steel components charged with G-16 mixture resulted in less change in sensitivity on storage at 500° F than did either brass or unplated steel components. These results indicate a potentially profitable field of investigation, since it appears likely that other plating materials may be even better than copper.

Investigation of several priming mixture ingredients did not disclose any new formulation which could be considered superior to G-11 and G-16 mixtures for use at elevated temperatures. The evaluation of P-4 mixture showed that there is a steady desensitization at 400° F under all the conditions tested. Best results, obtained with shellac-coated brass components, showed good sensitivity after two weeks but not after three weeks.

RECOMMENDATIONS

Since none of the primers exhibited any useful life at 600° F, it is recommended that additional studies be conducted to define and resolve the problem areas noted. These studies are also a necessary prior step to the definition of a development specification for a higher temperature percussion primer for PAD.

Although the G-16 percussion primer evidences a limited capability for operation at temperatures above 400° F, its uses above this temperature would have to be under carefully prescribed conditions. Determination of performance requirements for a specific application above 400° F would require further investigation. The nature and duration of the primer environment in the interval between high temperature storage and testing should be investigated to determine the cause for loss in sensitivity found between the time of removal from the high temperature oven and testing.

Additional studies should be conducted to determine future requirements for improved primer components, component materials, and primer mixtures, to satisfy the demands of more stringent operational conditions. Because of the encouraging results obtained with copper-plated steel components, it is recommended that a study be made of steel and brass components plated with various inert metals as a means of improving stability at temperatures up to 600° F.

DISTRIBUTION

U.S.ARMY

1 - Hq, U.S.Army Materiel Command
Attn: AMCRD-DE-W
Washington, D. C. 20315

1 - Attn: AMCRD-DE-MO

1 - Attn: AMCPM

1 - Hq, U.S.Army Munitions Command
Attn; Technical Information Div
Dover, N.J. 07801

1 - Attn: AMSMU-RE-E

1 - Attn: AMSMU-RE-A

1 - Attn: AMSMU-RE-N

1 - Attn: AMSMU-RE-P

1 - Attn: AMSMU-LA, USAF Liaison Off

1 - Attn: AMSMU-LC, CDC Liaison Off

1 - Attn: AMSMU-LM, USMC Liaison Off

1 - Hq, U.S.Army Mobility Command
Attn: Technical Information Div
Warren, Mich. 48090

1 - Attn: AMSMO-RR

1 - Attn: AMSMO-RD

1 - Attn: AMSMO-RL

1 - Attn: AMSMO-PR

1 - Attn: Liaison Office, CDC

1 - U.S.Army Natick Laboratory
Attn: AMXRD-ADED
Natick, Mass. 01762

1 - Hq, U.S.Army Test & Evaluation Command
Attn: Dir: Aviation Mat'l Testing
Aberdeen Proving Ground, Md. 21005

1 - Attn: Dir, Gen'l E uipment Testing

1 - Attn: Liaison Office, CDC

2 - Commanding Officer
Attn: Technical Library, Bldg 313
Aberdeen Proving Ground, Md. 21005

1 - Hq, U.S.Army Weapons Command
Attn: Technical Information Div
Rock Island Arsenal
Rock Island, Ill. 61202

1 - Hq, U.S.Army Missile Command
Attn: Dir, R&D Directorate
Redstone Arsenal
Huntsville, Ala. 35809

1 - Hq, U.S.Army Electronics Command
Attn: Dir, Res & Dev, AMSEL-RD
Fort Monmouth, N.J. 07703

1 - Hq, U.S.Army Supply & Maintenance Cmd
Attn: Dir of Maintenance, AMSSM-M
Washington 25, D. C.

1 - Attn: Dir of Supply, AMSSM-S

1 - Hq, U.S.Army Aviation & Surface Materiel Command
Attn: Technical Director
P.O. Box 209, Main Office
St. Louis, Mo. 63166

1 - Attn: Director, Engineering

1 - Attn: Liaison Office, CDC

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) FRANKFORD ARSENAL, Philadelphia, Pa. 19137 Attn: SMUFA L3100	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP NA

3. REPORT TITLE
Feasibility Study of Percussion Primers between 400° and 600° F

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Technical Research Study

5. AUTHOR(S) (Last name, first name, initial)
JOHNSON, THEODORE B.
KENNEY, JOSEPH F.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
October 1965	23	Two

8a. CONTRACT OR GRANT NO. AF MIPR 33-657-3-1375A-188	9a. ORIGINATOR'S REPORT NUMBER(S) M66-9-1
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) SEG-TR-65-49
d.	

10. AVAILABILITY/LIMITATION NOTICES
Qualified requesters may obtain copies from DDC. Release to CFSTI is not authorized.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Systems Engineering Group (SEMCS) Air Force Systems Command

13. ABSTRACT Experimental work was conducted on previously developed percussion primers to determine functioning characteristics in the temperature range of 400° to 600° F. Feasibility studies were also conducted with various priming mixtures and metallic components of the primers to determine practicability of a primer which would be stable after several hours in storage at temperatures up to 600° F. Two primers, designated No. 73 (G-11) and No. 73 (G-16), were tested while being held at the high storage temperatures and, also, at ambient conditions after cooling from the storage temperature.

The sensitivity of No. 73 (G-11) primed, foiled cases was determined after exposure at 450° F. The results indicate that no reliance can be placed on these primers after an exposure of approx one week at 450° F. G-11 primers may burn or explode after several hours at 500° F.

The sensitivity of No. 73 (G-16) primed, foiled cases was determined after exposure at 450°, 500°, 550°, and 600° F. The period of usefulness appears to range from several weeks at 450° F to several hours at 550° F. G-16 primers exploded after less than 30 minutes in a 600° F environment.

In the evaluation of ideas for primer components that might yield primers with increased temperature stability, it was shown that copper-plated steel components charged with G-16 mixture resulted in less change in sensitivity on storage at 500° F than did either brass or unplated steel components.

DD FORM 1 JAN 64 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Propellant Actuated Devices						
Primers, Percussion						
Primer Mixtures						
Primer Testing						
Primer Sensitivity						
Primer Components						
Temperature Stability						
Temperature Conditioning						
Igniter Components						
Ammunition, Small Arms						
Ballistics						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
_______________________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
_______________________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
_______________________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.